REMARKS

Claims 76-79 and 81-84 are pending in the application.

Claims 76-79 and 81-84 are rejected

Claims 79, 81 and 84 have been objected to

Claims 78 and 79 are rejected under 35 U.S.C. § 112, first paragraph, as based on a disclosure which is not enabling.

Claims 82-84 are rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement.

Claims 76-79 and 81-84 are rejected under U.S.C. 101 because the claimed invention is directed to non-statutory subject matter.

Claims 82-84, are rejected under 35 U.S.C. § 102(a) as being anticipated by McMillan and Amla, Automatic Abstraction without Counterexamples, (McMillan hereinafter). (see IDS dated 8/16/08).

Claims 81, 76, and 77 are rejected under 35 U.S.C. § 102 (e) as being anticipated by McMillan et al., (McMillan (2) hereafter), U.S. Patent 7,406,405.

Claims 78 and 79 are rejected under 35 U.S.C. § 103(a) as being unpatentable over McMillan (2) as applied to claim 81 above taken in view of Marques-Silva and Sakallah, (Marques-Silva hereinafter), GRASP: A Search Algorithm for Propositional Satisfiability (see reference [6] listed in the Application description pg. 3 or PTO 892 Notice of Reference Cited dated 5/15/07).

Examiner Interview

The Applicants thank the Examiner for the telephonic interview with the Applicant and their representative on September 22, 2009. The Applicants have amended the claims as per the Examiner's suggestion to recite clearly that **only the flip-flops and external constraints are marked**.

Claim Rejections Under 35 U.S.C. 101 and 112

The claims have been amended. The amended claims are believed to be proper under section 101 and 112.

Claim 81 is amended to include marking of only the flip-flops and external constraint nodes in the circuit design and deriving an abstract model by including combinational fanin cones of the marked flip-flops and external constraint nodes. These steps are described at multiple places in the description, including Page 8, paragraph [36], Page 10, paragraph [40] and Page 30, paragraph [112]. Step (c) of Claim 81 is a background step for using an abstract model, such that correctness on an abstract model indicates that the original design is correct. For example, one method of checking correctness on the abstract model is described on Page 12, paragraph [45]. This and other methods are described again in Section 6, starting on Page 38. This step describes how the abstract model is used to produce a tangible result. The background verification method based on bounded model checking in Claim 81 is described on Page 39, paragraph [132]. The novel steps are described again in paragraphs [133], [134].

Amended Claim 77 is supported at least by Page 8, paragraph [36] and Page 10, paragraph [40]. Claim 78 is supported at least by Page 9, paragraphs [37], [38]. Amended claims 79 and 80

do not make any reference to a dummy variable. Instead, these claims focus on exactly what is done. Notably, a constraint (m) is replaced by (m+y)(m+(not(y)), where y is a fresh variable not used in rest of the satisfiability formula. Support for Claim 79 includes at least Page 50, paragraph [163], where **y'** denotes not(y) and Page 52, paragraph [168] which describes use of a modified constraint (called a lazy constraint) for the initial value constraints of a latch. Amended claim 80 us supported at least by Page 50, paragraph [163], where **y'** denotes not(y) and Page 52, paragraph [169] which describes use of a modified constraint (called a lazy constraint) for the external environment constraint.

The modified constraints are sued to potentially reduce the number of flip-flops in the derived abstract models, these reductions making the abstract model easier to verify. This is shown in the experimental results in Table 3, page 58. Note that the number of flip-flops (#FF) in the derived abstract model is less when using the modified constraints (shown under "With Lazy PPI Constraints"), in comparison to the abstract model derived without use of modified constraints (shown under "No Lazy PPI Constraints").

Claim 82 is amended to add a tangible result and to focus on the iterative steps. Specifically, there is an inner loop formed by repetition of steps (a-c) on a given design/model, where bounded model checking is used iteratively to derive an abstract model whose size does not change as depth of unrolling is increased. There is also an outer loop formed by repetition of steps (a-d) on a newly derived abstract model – this constitutes an abstraction loop, where model A_n is used to derive a new abstract model A_{n+1}. The outer loop is advantageous in successively reducing the size of the derived abstract model. The support for the amended claim includes at least Page 10, paragraph

[41] and Page 42, paragraph [138], with the outer loop shown in Figure 8. The advantageous effect of multiple abstraction iterations (the outer loop) on reducing the size of the abstract models is shown clearly in our experimental results described in Table 1, page 54. For example, for design D1, the number of flip-flops in the abstract model (#FF) is reduced from 1269 in the first abstraction iteration (shown as Iteration 1), to 113 in the sixth abstraction iteration (shown as Iteration 6). This successive reduction makes the abstract models easier to verify.

Prior Art Rejections

1. McMillan and Amla, Automatic abstraction with counterexamples, US 7,406,405.

The present invention is completely different from the suggestions of McMillan and Amla. Notably, there are differences at least in the way that an abstracted design description is generated by their abstractor (explained in (a) below), and in the overall iterative verification procedure (explained in (b) below).

(a) In McMillan and Amla, "abstracting the design description comprises deleting a constraint of the design description when the constraint's clauses are not used in any inference step of the proof" (see, for example, Claim # 5 of US Patent 7,406,405).

In contrast, the present invention is based on marking **only** the flip-flops and external constraint nodes in the sequential design (Claim 81, step a). This does not require examining all constraints in the design description. Therefore, the inventive method is more efficient. Furthermore, the abstract model according to the invention consists of combinational fanin cones of *marked* flip-flops and external constraint nodes (Claim 75, step b). In particular, the abstract model may include a constraint of the design description

even when the constraint's clauses are not used in any inference step of the proof. This difference makes the abstract model according to the invention more precise than the one suggested by Macmillan and Amla. The present invention produces less spurious behaviors. (Spurious behaviors are those behaviors that are not exhibited in the real design.)

(b) The method of McMillan and Amla derives an abstract model and checks it for correctness at every depth of unrolling of the circuit design. In contrast, the iterative method of the present invention (Claim 82) derives an abstract model at every depth of unrolling, but only checks it for correctness after its size does not change (step f, Claim 81). Furthermore, the abstraction steps (step e, Claim 82) are repeated again on the derived abstract model. Therefore, the iterative method of the present invention is more efficient due to the following reasons:

- The present invention avoids some expensive verification checks on "intermediate" abstract models during unrolling of the circuit design in the inner loop.
- the derived abstract models of the present invention are smaller, because the present invention repeats the abstraction steps (a-d, Claim 81) again on a derived abstract model, and keep repeating this abstraction process (the outer loop) until the size of the derived abstract model does not change any more.

The advantageous effect of multiple abstraction iterations (the outer loop in the present invention) on reducing the size of the abstract models is shown clearly in the experimental results described in Table 1, page 54. For example, for design D1, the number of flip-flops

in the abstract model (#FF) is reduced from 1269 in the first abstraction iteration (shown as Iteration 1), to 113 in the sixth abstraction iteration (shown as Iteration 6).

For this design, McMillan and Amla's method (even if they used the abstraction method in Claim 81) would have stopped after the first abstraction iteration (Iteration 1) resulting in a derived abstract model with 1269 flip-flops. In practice, it is much easier to verify an abstract model with 113 flip-flops, than to verify an abstract model with 1269 flip-flops.

2. Marquez-Silva and Sakallah, GRASP: A search algorithm for propositional satisfiability

The method by Marquez-Silva et al. has been cited because of the mention of "dummy variables" in our earlier claims. The amended claims (79 and 80) do not mention dummy variables The amended claims are dependent claims of Claim 81, which discusses a method for verifying a sequential design by deriving an abstract model from the unsatisfiable core generated from a proof of unsatisfiability by a solver. Marquez-Silva et al. do not discuss at all the unsatisfiable core, or derivation of an abstract model from the unsatisfiable core.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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